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Study of Diversity of Freshwater Algae in Some Areas of Lahore City

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ABSTRACT: Total 35 algal species belonging to 15 genera, 11 familes, 5 orders, 5 classes and 3 phylum Cyanophycota, Chlorophycota and Bacillariophycota. They were collected from freshwater of some areas (GCU and Nasir Bagh) of Lahore city during October 2017 to March 2018. All were taxonomically investigated upto specie level. Following species were identified:
Aphanothece endophytica G.M. Smith, *Aphanothece nidulans* P. Richter *Chroococcus limenticus* var. distans G.M. Smith, *Chroococcus minor* (Kützing) Lemmermann, *Chroococcus tenax* (Kirchner) Hieronymus, *Chroococcusturgidus* (Kützing) Nägeli, *Chroococus varius* A. Braun, *Anabaena affinis* Lemmermann, *Oscillatoria amoena* (Kützing) Gomont, *Oscillatoria amphibia* C. Agardh *ex* Gomont, *Oscillatoria angustissimaOscillatoria formosa* Broy *ex* Gomont, *Oscillatoria prolifica* (Grev.) Gomont, *Oscillatoria subbrevis* Schmidle, *Oscillatoria tenuis* C. Agardh *ex* Gomont, *Oscillatoria terebriformis* C. Agardh, *Spirulina subsala* (Oersted) *ex* Gomont, *Lyngbya arboricola* Bruhlet Bruh, *Lyngbya tylorii* Drouet & Strickland, *Calothrix fusca* (Kützing) Bornet & Flahault, *Ulothrix aequalis* Kützing, *Ulothrix tenuissima* Kützing, *Oedogonium behemicum* Hirn, *Cymbella ehrengbergii* Kützing, *Cymbella turgida*, *Cymbella venticosa*, *Navicula confervacea* (Kützing) Grun. var. *confervacea*,*Navicula knsnesis* Meister,*Navicula mutica* Kützing var. mutica, *Navicula lanceolata* Kützing, *Navicula viridula* var. *avenacea* (Bréb. *ex* Grun.), *Achanthes hungarica* (Grunow) Grunow in Cleve *et* Grunow 1880, *Achnanthes minutissima* (Kützing) Cleve, *Cyclotella operculata* (C.A. Agardh) Brebisson, *Pinuularia interrupta* W. Smith .

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I. INTRODUCTION

Lahore is the capital of Punjab. In the country, it is second largest city. It is located at latitude 31°32′59″N and longitude 74°20′37 E. Its elevation is 217m (712ft). Lahore climate is hot semi arid. During May, June and July temperature soar to 40°C-48°C. Monsoon season starts from June till September and from December till February.During winter season hailstorm occurs.

Biodiversity and seasonal variations of fresh water algae was reported by several phycologists. Ghose (1924) worked on the algal flora of Punjab province. He described number of blue green algae from Lahore. Later on Masud-ul-hassan (1978a, 1980, Masud-ul-hasan and Zaibun-Nisa 1986, Masud-ul-hasan and Batool 1987, Masud-ul-hasan and yunus 1989) has reported some algae including Cyanophyta, which were collected from Lahore ponds Several studies were made on the algal flora of NWFP (Faridi 1955, 1956, 1975, 1977a.b, 1978, Siddiqi & Faridi 1964, Shameel 1978, Sarim 1991), Azad Kashmir (Faridi 1971), Balochistan (Aisha and Shameel 1995, Zaidi 2000, Langangen and Leghari 2001, Shameel 2002), and Sindh (Aizaz and Farooqui 1972, Farzana and Nizamuddin 1979).

Leghari *et al.,* (2003) ecologically studied the algal flora of Wah garden district Attock , Pakistan . Algal samples were collected from June 2000 to May 2001. Algal flora of Kunhar river was studied first time, during January 1998 to July 1998 (Leghari *et al*., 2001).

There are many physical and chemical factors which affect the algal growth and community structure, like; light, temperature, organic nutrients, pH, grazing and seasonality, carbonates, bicarbonates, calcium, megnicium, and cloride contents in water. These factors changed the algal morphology.Some algal species have ability to face stress environment and some species are unable to adopt themselves in stress environment (Schlichting, 1974). Different species grow at different temperatures, for example thermal blue green algae grow at 74°C (Brock *et al*.,1967). Green algae grow below 47°C. Diatoms can grow in temperature upto 60°C (Chang,1966). Light quality also produces changes in the growth and survival of algae. In the presence of nutrient in culture, algal species can grow in the absence of light for several months. Change in pH can also

affect the algalgrowth (Prescott,1962). Blue green algae grow above a pH of 8 (Brock, 1973) and they cannot grow at a pH below 4.

II. MATERIALS AND METHODS

Selection of area

Firstly all the taps and fountains of GC University Lahore and Nasir garden were surveyed. Then those stations were selected where the algal samples were more. Four sampling sites were selected from GCUL and two selected from Nasir garden. GCUL located at latitude $31^0$34′24.85″N and longitude $74^0$18′28.55′ E. Its elevation is 728 ft. Nasir garden located at latitude $31^0$34′15.45″ N and longitude $74^0$18′22.13′ E. Its elevation is 698ft near Katchary Road Lahore.

Sampling sites

1. GCU Scholar Garden Tap.
2. GCU Chemistry Department Tap.
3. GCU Bukhari Back Tap.
4. GCU Oval Ground Tap.
5. Nasir Garden Tap.
6. Nasir Garden Fountain.

Collection of samples

Transparent plastic bottols were used for the collection of water and algal samples. Samples were collected with the intervals of fifteen days. Bottols were labeled according to the dates, sampling sites and sample numbers. Water was added into the bottols before collection. Then algal samples were put into the bottols with the help of forceps and spatula. Water samples were collected into the separate bottols.

Storage of samples

Algal samples were preserved by the addition of 1 to 2 ml of 4% formalin with the intervals of one month (formalin was prepared by addition of 4ml of formalin in 96ml of distilled water). Samples stored in Phycology Lab., Botany Department, GC University Lahore.

Field observation

During collection altitude and latitude by GPS (Global Position System), air and water temperature by thermometer, pH of water by pH meter and climate were determined.

Study of material in laboratory

Small amount of algal sample was taken from bottle with the help of forceps and needle, and was placed on the clean slide. The material was spread with the help of needle on the slide and one drop of water was added on the material. Coverslip was placed on the material and gently pressed with the help of thumb to remove water droplets from the material. Then the sample was observed under high and low magnification power of microscope. Shape of chloroplast and shape of cell were examined. Length and width of the cells were measured via ocular micrometer. Camera Lucida was used for measurements. The diagrams were sketched on the butter paper by using black pointer.

After recording measurements and observing the sample material, the material was again poured in the bottle. Slides were washed with sample water then with tap water.

Identification of collected material:

The observed algal samples were identified with standard literature. For the purpose of identification Desikachary, Prescott (1962) and M.C cookies were consulted.

III. RESULTS AND DISCUSSIONS

Total 35 algal species belonging to 15 genera, 10 familes, 5 orders, 5 classes and 3 phylum Cyanophycota, Chlorophycota and Bacillariophycota. They were collected from freshwater of some areas (GCU and Nasir Bagh) of Lahore city during October 2017 to March 2018. They were identified up to species level on the basis of their morphological and cytological features. They all are systematically arranged according to newly proposed Shameelian classification (Shameel 2001, 2008) presented in the following pages:

TABLE 1. Sampling sites of different areas of Lahore city

No.	Sampling sites	Latitude (N)	Longitude (E)
1	Bukhari Auditorium (back side)	31° 34′483"	74° 18′486"
2	Oval Ground	31° 34′335"	74° 18′413"
3	Chemistry Department	31° 34′919"	74° 18′201"
4	ScholarGarden	31° 34′392"	74° 18′465"
5	Nasir Bagh (fountain)	31° 34′254"	74° 18′398"
6	Nasir Bagh (tap)	31° 34′259"	74° 18′435"

KINGDOM MONERA
Phylum Cyanophycota
Class Chroocophyceae
Order Chroccoccales
Family Chroococaceae
***Aphanocapsa* Nägeli**
A. endophytica G.M. Smith 1920: 42
Aphanothece* Nägeli *nom cons
A. nidulans P. Richter 1884: 128
***Chroococcus* Nägeli**
C. limenticus var. distans G.M. Smith 1916: 481
C. minor (Kützing) Lemmermann 1909: 102
C. tenax(Kirchner) Hieronymus 1949: 246
C. turgidus (Kützing) Nägeli 1849: 46
C. varius A. Braun 1861
Class Nostocophyceae
Order Nostocales
Family Nostocaceae
***Anabaena* Bory**
A. affinis Lemmermann 1898: 261
Family Oscillatoriaceae
***Oscillatoria* Vaucher*ex* Gomont**
O. amoena (Kützing) Gomont 1892: 225
O. amphibia C. Agardh*ex* Gomont 1827: 632
O. angustissima West & West 1897: 300
O. formosa Broy *ex* Gomont 1827: 474
O. prolifica (Grev.) Gomont 1892: 205
O. subbrevis Schmidle 1901: 243
O. tenuis C. Agardh *ex* Gomont 1892: 221
O. terebriformis C.Agardh 1827: 634
***Spirulina* Turpin**
S. subsala (Oersted) *ex* Gomont
***Lyngbya* Agardh**
L. arboricola Bruhlet Bruhl
L. tylorii Drouet & Strickland 1940: 631
Family Ravulariaceae
***Calothrix* C. Agardh *ex* Bornet *et* Flahault m**
C. fusca (Kützing) Bornet& Flahault 1886: 364
KINGDOM PHYCOTA
Phylum Chlorophycota
Class Ulvophyceae
Order Ulotrichales

Family Ulotrichaceae
***Ulothrix* Kützing**
*U. aequalis*Kützing
U. tenuissima Kützing 1833: 518
Class Zygonemophyceae
Order Oedogoniaceae
Family Oedogoniaceae
***Oedogonium* Link**
O. behemicum Hirn 1900:169
KINGDOM PROTISTA
Phylum Bacillarophycota
Class Bacillarophyceae
Order Bacillariales
Family Cymbellaceae
***Cymbella* C. Agardh**
C. ehrengbergii Kützing
*C. turgida*Hustedt 1930
*C. venticosa*Hustedt 1930
Family Naviculaceae
***Navicula* Boryde Saint Vincent *emend*. Cleve**
N. confervacea(Kützing) Grun. var. confervacea 1844: 109
N. knsnesis Meister
N. mutica Kützing Var. mutica 1844: 93
N. lanceolata Kützing
*N. viridula*var. *avenacea* (Bréb. *ex* Grun.) 1878: 112
Family Achnanthaceae
***Achnanthes* Bory**
*A. hungarica***(**Grunow) Grunow in Cleve *et* Grunow 1880
A.minutissima (Kützing) Cleve
Family Cyclotellaceae
***Cyclotella* (Kutzing) Brebisson**
C. operculata(C.A. Agardh) Brebisson 1838: 20
Family Pinnulariaceae
***Pinularia* Ehrenberg**
P. interrupta W. Smith 1853

KINGDOM MONERA

Prokaryotic organisms**.**

Phylum Cyanophycota

Nucleus, plastids and cell organelles are absent. No sexual reproduction**.**

Class Chroocophyceae

Unicellular, colonial form or palmelloid.

Order Chroococales

Cells loosely bound into gelatinous material, irregular colonies, reproduction by endospore or cell division.

Family Chroococcaceae

Cells usually spherical, ellipsoidal, seldom spindle shaped, cylindrical, single or forming colonies, membrane thick, mucilaginous, often lamelated, colony shapeless, spherical, tubular, hemispherical, cell division in two or three directions.

***Aphanocapsa* Nägeli**

A globular, ovate or amorphous mass, gelatinous and free floating, homogeneous colonial mucilage, contents homogeneous or granular, pale gray-green to bright blue green. Cels often with a thin more or less gelatinized individual sheath, division in two directions, often two, four and sometime many within a common mucilaginous envelop of parent cells; nanocytes present in some species, formed by repeated divisions.

1. Cells spherical……..*C. limenticus*
   Cells in group……..2
2. Cells in group……..…*C. tenax*
   Cells are scattered……...*C. minor*

3. Cells single or 2-4 together…….*C. turgidus*
Cells in colonies……..*C. varius*

***Aphanocapsa endophytica* G. M. Smith 1920: 42**

(Fig. No. 1)

References: Prescott, 1962.

Taxonomic characters: Cells solitary or arranged in small clumps, homogeneous cell contents, pale to brown blue green, cells 2µ in diameter.

***Aphanothece* Nägeli nom cons**

Cells ovate, sub cylindrical or oblong, straight, slightly bent, dense, sedentary or free floating, some times subaerial, cell contents granular, gray , bright blue-green , olive, no vacule, indistinct cell sheath, mucilage, homogeneous, some times lamellated, transverse division.

***Aphanothece nidulans* P. Richter 1884: 128**

(Fig. No. 2)

References: Forti, 1907; Geitler, 1932.

Taxonomic characters: cells cylindrical, broadly rounded at the apices, straight or slightly bent, thallus expanded irregularly, cells 1-2µ broad, up to 4µ long, blue-green, densely arranged, mucilage sheath mostly diffluent, yellow to brownish yellow or colourless, cell content pale blue-green.

***Chroococcus* Nägeli**

Cell spherical or subspherical, hemispherical, sheath of individual cell distinct, firm, generally lamelated, reproduction by cell division and fermentation of colonies.

***C. limenticus* var. distans G.M. Smith 1916: 481**

(Fig. No. 3)

References: Forti, 1907; Fremy, 1929; Geitler, 1932; Fremy, 1933.

Taxonomical charaters: Cells spherical or sub spherical after division, 4-32, free floating, mostly in a tabular gelatinous layer, without sheath cell diameter 6-12µ, with sheath 8-14µ diameter, sheath distinct or diffluent, unlamellated, colorless, colonial mucilage broad, cell division generally in two, seldom in three directions, cell contents gray, blue green. Olive green or yellowish.

***Chroococcus minor* (Kützing) Lemmermann 1909: 102**

(Fig. No.4)

References: Forti, 1907; Frémy, 1929; Geitler, 1932.

Taxonomic characters: A small gelatinous sheath attached and amorphous mass in which cells are scattered iregularly, in pairs or in large groups, individual cell sheath scarcely visible,sheath co,ourless, thin, cell content pale to bright blue-green, non granular, cells 3-4µ in diameter without sheath.

***Chroococcus tenax* (Kirchner) Hieronymus 1949: 246**

(Fig. No. 5)

References: Geitler, 1932; Desikachary, 1959.

Taxonomic characters: Cells mostly in groups of 2-4 and some times 8-16, olive or blue green colour, diameter without sheath 16-21µ and including sheath 20-26µ, sheath yellow to brown or colousless, thick, lemellated, 3-4 lamella.

***Chrcoococus turgidus*(Kützing) Nägeli 1849: 46**

(Fig. No. 6)

References: Forti, 1907; Fremy. 1929; Geitler, 1932; Desikachary, 1959; Gupta & Kumar, 1968; Faridi *et al.*, 1981.

Taxonomic characters: A free floating colony of 2-4 ovoid or hemispherical cells bounded in hyaline , lamellate colonial sheath, bright blue-green cells, 8-32µ diameter without sheath and 15-50µ width including sheath, sheath colourless, granular cell contents.

***Chroococcus varius* A. Braun 1861**

(Fig. No. 7)

References: : Forti 1907, Geitler 1932, Frémy 1929.

Taxonomic characters: Thallus gelatinous olive green or brownish; cells single or 2-4 together,globular, seldom more in small or big groups, without sheath 2-4µ, with sheath 4-8µ diameter, irregularly arranged, sheath apparently thick, colorless or yellowish or pale orange .

Class Nostocophyceae

Filamentous forms. With or without heterocysts, unbranched or branched, homotrichous or heterotrichous, reproduction by endospores, hormogonia, and akinetes.

Order Nostocales

Filamentous, heterocysts present, no true branching. Reproduction by akinetes and Hormogonia.

Family Nostocaceae

Trichomes free in a common mucilage, generally with cell in a single row; cells generally similar throughout, end cells sometimes attenuated with intercalary growth; sheath thick and gelatinous or thin and firm; heterocysts intercalary or terminal generally single, spores present or absent, formed in a definite manner beginning from near the heterocyst or in between two of them.

***Anabaena* Bory**

Filamentous, mostly gregarious, trichomes straight, flexuous, or spirally coiled, with or without sheath, cells torulose, barrel-shaped, or cylindrical, gonidia roud, ovate or cylindrical.

***Anabaena affinis* Lemmermann 1898: 261**

(Fig. No. 8)

References: Prescott, 1962.

Taxonomic characters: Trichomes straight or flexuous, solitary and free floating, mucilaginous sheath present, cells spherical to spheroidal, 5-6µ in diameter, heterocyst spherical, slightly larger than the vegetative cells, 7-10µ in diameter, gonodia short-cylindric, sometimes truncately rounded at the poles, scattered, solitary, 9-12µ diameter, 17-24µ long.

Family Oscillatoriaceae

Trichomes are unbranched with a single row of similar and uniformly broad cells.Sometimes tapering ends, branched or unbranched, straight filaments or regularly or irregularly spirally coiled. Intercalary and apical growth, spores and hetercysts are absent, hormogones present.

***Oscillatoria* Vaucher *ex* Gomont**

Elongated and filamentous, no sheath, straight ,or entangled and twisted. Scattered and solitary trichomes , smoothly rounded or swollen and apitates apical cell. Trichome ends are distinctly marked, pointed bent like a sickle or coiled like a screw. Length of cells in most of species is shorter than width. With or without cell wall constriction. Some times granules are present on either side. Trichomes divides to form hormogones. This genus may be represented by three species, that may be distinguished as follows:

1. Trichomes short……...……...….*O. amoena*
   Tricomesfree……....*O. subbrevis*
2. Cells 2-6µ, as long as broad……..…..*O. tenuis*

Cells 2-3µ, long than broad…….…….…..*O. amphibian*

3. Cells 2-3µ broad, 4-6µ long…….…...….*O. prolific*
   Cells4-6µ broad, 2.5-5µ long…… ...…….……..*O. formosa*

1 : *Oscillatoia amoena* (kützing) Gomont 1892: 225

(Fig. No.9)

References: Forti, 1907; Frémy, 1929; Geitler, 1932.

Taxonomic characters: Thallus more or less blue-green, straight trichomes, slightly constricted at the cross walls, ends attenuated, 2-5µ broad, 2-4.2µ long, apical cell broad, granulated septa, end cells 66apitates, broadly conical, 66apitates present.

***2. Oscillatoria amphibia* C. Agardh *ex* Gomont 1827:**

(Fig. No. 10)

References: Gomont, 1892b: 221; Forti, 1907: 169; Tilden, 1910: 73; Fremy, 1929: 213; Feldmann, 1937: 164; Desikachary, 1959: 229; Starmach, 1966: 344.

Taxonomic characters: Straight or curved trichomes, broadly rounded , smooth apical cell, cross walls of cells are not constricted, cells 2-3 times greater than width, cells 2-3µ broad and 4-5µ long, end cells rounded, apitates absent.

3*: Oscillatoria angustissima* West & West 1897: 300

(Fig. No. 11)

References: Forti, 1907; Geitler, 1932; Frémy, 1929.

Taxonomic characters: Thallus expanding, trichomes 0.6 broad, cells 1-2 times longer than broad, not constricted at the cross wall, not capitates. Ends not attenuated. Cell contents colorless, trichomes much entangled.

4: *Oscillatoria formosa* Broy *ex* Gomont 1827: 474

(Fig. No.12)

References: Gomont, 1892; Forti, 1907; Geitler 1932.

Taxonomiccharacters: Thallus blue green, straight trichomes, slightly constricted at cross walls, 4-6µ broad, bright blue-green, attenuated ends, quadrate cells, cells ½ as long as broad, 2.5-5µ long, granulated septa, apitates absent, not apitates.

5: *Oscillatoria prolifica* Gomont 1892: 205

(Fig. No. 13)

References: Forti, 1907; Geitler, 1932.

Taxonomic characters: Straight or curved trichomes, cross wall no constricted, attenuated ends, 2-3µ broad, 4-6µ long, granulated septa, gas vacuoles present, capitate end walls, with calyptras.

6. *Oscillatoria subbrevis* Schmidle 1901: 243

(Fig. No. 14)

References: Forti, 1907, Fremy, 1929; Geitler, 1932; Desikachary,1959; Vasishta, 960; Starmach, 1966; Masud-ul-Hassan, 1980; Faridi *et al.*,1981; Masud-ul-Hassan & Yunus, 1989.

Taxonomic characters: Trichomes free, planktonic, small or long (up to 77µ) single, 4.5-10µ broad, nearly straight, not attenuated at the apices; not granulated at the end walls; cells 1.5-3.5µ long, 4.5-8.2µ broad; end cell rounded, calyptras absent.

7: *Oscillatoria tenuis* C. Agardh Gomont 1892: 221

(Fig. No. 15)

References: Gomont, 1892b; Forti, 1907; Tilden, 1910; Fremy, 1929; 1933, Geitler, 1932; Desikachary, 1959; Starmach, 1966; Islam, 1976; Faridi et al., 1981; Masud-ul-Hasan and Zeb-un-NisA, 1986; Anagnostidis & Komarek, 1988.

Taxonomic characters: Blue green or olive green thallus, Stouter trichomes, 7.4-10µ diameter, cells 3-5µ broad; not atinuated at th apices: ells 2-6µ or up to 1/3 as long as broad, slightly constricted cross walls, more or less hemispherical with thickened outer membrane.

8*: Oscillatoria terebriformis* C.Agardh 1827: 634

(Fig. No. 16)

References: Agardh, 1827; Gomont, 1892; Forti, 1907; Geitler, 1932.

Taxonomic characters: Trichomes dark blue-steel in colour, spirally twisted, slightly tapering in the apical region, apical cell pointed or round, without capitate and calyptra, cells 4-7µ in diameter and 3-6µ long, not constricted at the cross walls.

***Spirulina* Turpin *ex* Gomont**

Trichomes unicellular or multicellular cylindrical, sheath absent; loosely or tightly coiled into a more or less regular spiral; apex of trichome usually not attenuated; cross-walls if present obscured; terminal cell rounded, without calyptra. Under this genus following species were distinguished

***Spirulina subsala* (Oersted) *ex* Gomont 1892**

(Fig.No.17)

References: Gomont, 1892b; Forti, 1907; Frémy,1929; Geitler, 1932; Desikachary, 1959.

General Character: trichome 2 µ broad, blue green toraddish violet, mostly somewhat irregular densely spiral coiled, rarely regularly coiled, sometimes loosely coiled forming a bright blue green or yellowish-green thallus, or single among other algae, spirals very close to each other, 3-5 µ broad. Among other algae or on dead leaves in stagnant waters.

***Lyngbya* Agardh**

Filamentous, uniseriate and unbranched trichomes, mucilaginous sheath present, planktonic and solitary, trichomes mostly cylindrical, and tapering very slightly, not capitate.

***Lyngbya arboricola*Bruhl *et* Biswas**

(Fig.No.18)

References: Geitler, 1932.

Taxonomical characters: Thallus forming a continous layer, when moist blue-green, when dry more odr less reddish brown, velvetty, filaments nearly straight or moderately flexuous, long 18-22µ broad. Sheath coloreles at first or when empty, mostly reddish brown, firm 1.5-2µ thick, homogenous or slightly stratified, often slightly transversely wrinkled, shallowly but distinctly constricted at the septa, septa not granulated, blue green, rounded at the extremity, cells usually 5-6 sometimes 6-10µ long, contents, blue green, densely granular.

***Lyngbya tylorii* Drouet & Strickland 1940: 631**

(Fig. No. 19)

References: Prescott, 1962.

Taxonomic characters: Filamentous, trichomes not tapering towards the apices, not constricted at the cross walls, 4-7µ in diameter, terminal cell broadly convex, cells quadrate, cell content granular, sheath thin and colourless, filaments long, 6-9µ in diameter.

Family Ravulariaceae

Trichomes with a single row of cells apices generally attenuated or tapering in hair, unbranched or falsely branched, sometimes with a distinct intercalary meristematic region and trichothallic growth; hair with elongated more or less vacuolated cells; heterocysts present or absent, when present basal, intercalary heterocysts also present in some; hormogones present; spores present or absent, when present single or in series. Only one genera was identified.

***Calothrix* C. Agardh *ex* Bornet *et* Flahault**

Filaments single or in small bundles, eaespitose, tomentose, pulvinate or penicillate: filaments arranged more or less parallel, mostly erect, unbranched or seldom, falsely branched: sheath mostly firm, sometimes seen only at the base: heterocysts mostly basal, seldom intercalary; spores when formed single or in series, next to the basal heterocyst.

***Calothrix fusca* (Kützing) Bornet 1886: 364**

(Fig. No. 20)

References: Bornet 1886; Forti 1907; Frémy 1929; Geitler 1932.

Taxonomic characters: Filaments single, bulbous at the base, 11-14µ diameter, tapering to long hair, sheath broad, colourless, discoid cells, heterocysts hemispherical, basal, single ordouble, smaller than the basal cell of trichome, diameter 9-12µ, vegetative cells 7-11µ in diameter and 1/3 as long aswide.

KINGDOM PROTOCTISTA

Coenocytic or simple, multicellular organism.

Phylum Chlorophycota

Filamentous, siphonacious or thalloid.

Class Ulvophyceae

Filamentous or thalloid algae, normal cell division, sexual reproduction by iso-, aniso or oogamy.

Order Ulotrichales

Filamentous, cells cylindrical, with a parietal chloroplast, one or more pyranoids,

Family Ulotrichaceae

Cylindrical, uniseriately arranged cells, gelatinous sheath present, parietal chloroplast, reproduction by zoospores, isogametes, vegetative proliferation and by palmella stages.

***Ulothrix* Kützing**

Filaments simple, unbranched, cylindrical cells, parietal chloroplast, asexual reproduction by 4-8 quadriflagellate zoospores and sexual reproduction by isogametes, palmella stages no un common.

1. Parietal chloroplast……*U. aequalis*

Broad chloroplast……..*U. tenuissima*

***Ulothrix aequalis* Kützing 1845: 197**

(Fig. No. 21)

References: Prescott, 1962**.**

Taxonomic characters: Filaments long, cells cylindrical, parietal chloroplast, cells 13-16µ in diameter and 18-30µ long.

***Ulothrix tenuissima* Kützing 1833: 518**

(Fig. No. 22)

References: Prescott, 1962.

Taxonomic characters: Filaments long, cells ylindrical, shorter than wide, 16-20µ in diameter, thin walled, not constricted at the end walls, chloroplast a broad band encirclingabout 2/3 of the circumference of the cell, 2 or many pyranoids.

Class Zygnemophyceae

Thallus filamentous, sexual reproduction by conjugation.

Order Oedogoniales

Filamentous, simple or branched, cells cylindrical, asexual reproduction by zoospores, sexual reproduction is heterogamous.

Family Oedogoniaceae

Filaments may be branched or unbranched, vegetative cells uninucleate, cylindrical or with ronded ends, chloroplast reticulate, parietal with many pyranoids, during cell division caps formed, asexual reproduction by stephankotic zoospores, sexual reproduction is oogamous, oogonia swollen, each with large egg.

***Oedogonium* Link**

Attached, unbranched filaments, cell cylindrical or enlarged towards the anterior end, parietal chloroplast with many pyranoids.

***Oedogonium bohemicum* Hirn 1900: 169**

(Pag. No. 23)

References: Prescott, 1962.

Taxonomic characters: Macrandrous; monoecious, vegetative cells capitellate, 14-15µ in diameter, 48-53µ long, oogonia solitary, globose, operculate, division superior, 40-42µ in diameter, smooth, 44-46µ long, oospore globose, filling the oogonia, smooth wall, 38-43µ in diameter, 38-43µ long, antheridia 10µ in diameter, 6-7µ long.

KINGDOM PROTISTA

Phylum Bacillarophycota

Flagellum on sperm only; cell wall in bipartite, sculptured frustules, outer epitheca and inner hypotheca.

Class Bacillarophyceae

Some characteristics as have been mentioned above under the decription of the phylum.

Order Bacillariales

Pennate or trellisoid ornamentation; many chloroplasts; no raphe; resing spores formed, motile spermatozoids with a single tinsel flagellum; sexual reproduction by oogamy.

Family Cymbellaceae

Valve is longitudinally asymmetrical due to the fact that it's one side is convex and the other side less convex and straight; frustules are symmetrical in all other planes; valve consists of only striae; as seen in gridle view, frustules are symmetrical in both axes; single large Chromatophore is within a cell; auxospore formation takes place.

***Cymbella* C. Agardh**

Frustules asymmetrical, solitary or in colonies, free floating or epiphytic, sessile or borne on stalk or enclosed in gelatinous tubes; gridle straight or nearly sub rectangular; valve sublunate, attenuated from the middle towards the obtuse ends; striae punctuate, radiate, delicate or coarse; raphe arched, excentric with central and polar nodules; axial area narrow or broad, slightly dilated in the middle, with one or more stigmas, terminal fissures or curved toward the dorsal margin; chrmatophore one or more plate like.

1. Raphe slightly excentric…….*C. ehrengbergii*

Raphe straight……..…...2

2. Cells 30-100µ long…….....*C. tugida*

Cells 10-40µ long……...*C. ventricosa*

***Cymbella ehrengbergii* Kützing**

(fig. No. 24**)**

References: Starmach 1964; Tariq-Ali 2006a.

General Characters: Valve elliptic-lanceolate, ends obtuse; striae radiate, coarsely punctuate; raphe straight, slightly excentric; axial area distinct, widened in the middle; 59.2µm long and 18.5µm broad.

***Cymbella turgida* Hustedt 1930**

(Fig. No. 25)

References: Hustedt, 1930**.**

Taxonomical characters: Cells 30-100µ long, 9-25 wide, 7-9 striae in 10µ, similar to C ventricosa, but larger and with more conspicuous punctae.

***Cymbella verticosa*Hustedt 1930**

(Fig. No. 26)

References: Hustedt, 1930**.**

Taxonomical characters: Cells 10-40µ long, 5-12µ wide, 12-18 striae in 10µ, raphe straight.

Family Naviculaceae

Frustules of values are symmetrical at both axes. Valve may be elliptical ,lanceolate or boat shaped in outline. The sagittal axis is usually linear, it may be sigmoid. Each valve has a raphe with distinct central and polar nodules. Valves have transverse or striae. There were two laminate chromatophores in each specimen.

***Navicula Boryde* Saint Vincent *emend.* Cleve**

Frustules free-floating, solitary or in colonies; girdle straight, rectangular; valve linear, lanceolate or fusiform; ends capitate, rounded or rostrate; raphe straight with central and polar nodules; striae or costae transverse, parallel or radiate; axial area narrow, linear; chromatophores two, laminate, lie on both sides of the valve with a bridge like connection in the middle; sometimes they split up into numerous, small, rounded granules.

1. Striae visible in center……..…*N. knsnesis*

Striae puncta in center……..*N. mutica*

2. Valve narrow……*N. confervaceae*
Valve lanceolate…….. 3
3. Cels 30-80 long……....*N. viridula*
Cells 20-50 long……...*N. lanceolata*

***Navicula confervacea* (Kützing) 1844: 109**

(Fig. No. 27)

References:Kützing, 1844.
Taxonomical characters: Valve lanceolate, ends usually rostrate but sometime obtuse,axial area near ends of the valve narrow, widening into a broad, lanceolate area which extends over most of the valve, median ends of the raphe somewhat distant from each other, striae radiate throughout tha valve, striae 20-24 in 10µ. Length 13-25µ, breath 4-7µ.

***Navicula knsnesis* Meister**

(Fig. No. 28)

References: Tariq-Ali *et al*. 2006.
Taxonomical characters: Frustules 14 long and 3 broad, striae only visibe at the center.

***Navicula mutica*Kützing 1844: 93**

(Fig. No. 29)

References:Kützing 1844.
Taxonomical characters: Cells 10-40µ long, 7-12µ wide, 15-20 striae in 10µ, single eccentric punctain the central area.

***Navicula lanceolata* Kützing**

(Fig. No. 30)

References:Kützing, 1844.
Taxonomic characters: Valve lanceolate, narrowed toward the ends which are rounded or slightly attenuate-rounded. Axial area narrow, distinct. Central area large, orbicular. Straie lineate-radiatethroughout most of the valve, becoming convergent at the ends; regularly shortened about thecentral area. Striae, usually about 10 in 10µ in the middle of the valve to 14 in 1oµ at the ends. Length 20-50µ, but usually less than 40µ. Breath, 6.5-12µ. This species is characterized by the large orbicular central area, the shape of the valve, and the angle and number of striae**.**

Navicula viridula

(Fig. No. 31)

References:Østrup, 1908; Nizamuddin 1984; Szabó et al. 2005.
Taxonomical characters: Cells 36-80µ long, 10-15µ wide, 10 striae in 10µ, central arearounded.

Family Achnanthaceae

Frustules individual or united in groups of varying numbers. Most forms are epiphytic, Thefrustules grow adnate, stalked or in colonies or chains. Valves linear, lanceolate, to elliptical, usually bent or arched apically or transpically, intercalary bands, septa and pseudosepta are rare.

***Achnanthes* Bory de Saint Vincent**

Valves elliptical, without produce or protracted and distinct ends. Pseudoraphe valve mostly moderately to strong convex, raphe valve convex to more nearly flat. Opposing valve usually with different striae pattern and structure. The raphe valve striae are usually punctuate. Members of this genus appear appear to be epiphytic, particularly on other algae and higher aquatic plants.

1. Frustules monoraphid……. *A. minutissima*
Frustles free floating……....*A. hungarica*

***Achnanthes hungarica*Grunow in Cleve *et* Grunow 1880**

(Fig. No. 32)

References: Nizamuddin 1984; West 1904.
Taxonomical characters: Frustules epiphytic and free floating, valve oblong, lanceolate, endsacute and sub acute, striae 29µm long and 7µm broad.

***Achnanthes minutissima* (Kützing) Cleve**

(Fig.No. 33)

References:Kützing, 1833.
General characters: Cells are solitary or in very short chains, often attached to the substrate by a stalk. Frustules are monoraphid with a valve raphe concave and convex raphe less valve. The valves are linear-lanceolate with ends slightly drawn-out or slightly capitate, 1-4 µm in width, 5-25 µm in length. Central external raphe ends are simple, terminal raphe fissures are short, almost straight, or absent. Internally, the central raphe ends are facing in opposite directions. Striae are radiate across both valves, 25-35 in 10 microns. Striae are

constituted by a row of small regions. The striae are often interrupted in the central part of the valve raphe to form a band symmetrical or asymmetrical. A row of elongated areolae is present on the valve mantle. External opening of areolae areolas vary in shape from circular to elongated slots transapically. Internal openings of the areolae are elliptical, occluded by hymen perforated by pores of small size.

Family Thalassiosiraceae

Frustules germinate, girdle rectangular, valve disc shaped, punctuate, with radiating striae, scattered granules, many rounded chromatophore.

Cyclotella (Kützing) Brebisson

Frustules solitary or germinate, girdle rectangular or with undulate side, valve disc shape, having to concentric areas, inner one smooth or with scattered granules outer one with finely punctuate radiating striae, chromatophore many, rounded, microspores formed within the cell.

***C. operculata* (C.A. Agardh) Brebisson 1838: 20**

(Fig. No. 34)

References: Nizamuddin, 1984: 42; Starmach, 1964: 106.

Taxonomical characters: Valve linear-elliptical to linear-lanceolate with obtuse, subcuneate apices with are sometimes set off by a subtile, constriction of the valve margins. Raphe valve with narrow, linear axial area, central area broad, raphe filiform, proximal ends rather close, striae slightly radiate throughout, lineae difficult to resolve.

Family Pinnulariaceae

Frustules solitary and free floating; girdle linear, rectangular or broadly elliptical; valve linearor lanceolate, sublunate; raphae straight, arcuate with central and polar nodules; straie transverse, punctuate, parallel or radiate; chromatophores two or more with pyrenoids.

***Pinnularia* Ehrenberg 1843**

Frustules solitary and free-floating; girdle linear, rectangular; valve linear, sometimes gibbous in the middle; ends broadly obtuse; raphe straight, central and polar nodules expanded; axial area broad, terminal fissures straight or sigmoid; striae or costae; parallel or radiate with internal opening; chromatphores two with pyrenoids.

***Pinnularia interrupta* W.Smith 1853**

(Fig.No. 35)

References: Szabó *et al.* 2005

General Character: valve linear with slightly convex sides, ends capitate, axial area dilated in the middle, striae delicate; 52-56µ long and 7-12µ.

figures

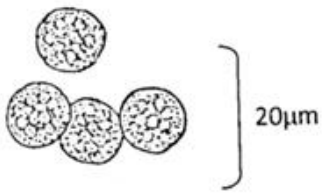

Fig. 1. *Aphanocapsa endophytica*

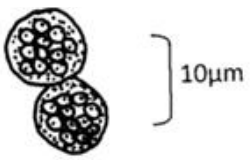

Fig. 2. *Aphanothece nidulans*

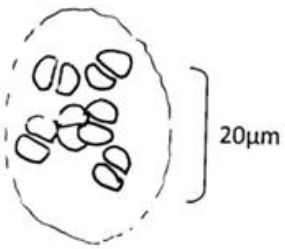

Fig.3. *Chroococcus limenticus*

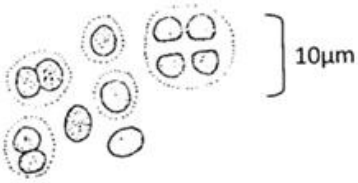

Fig.4. *Chroococcus minor*

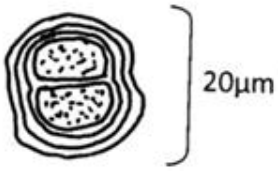

Fig. 5. *Chroococcus tenax*

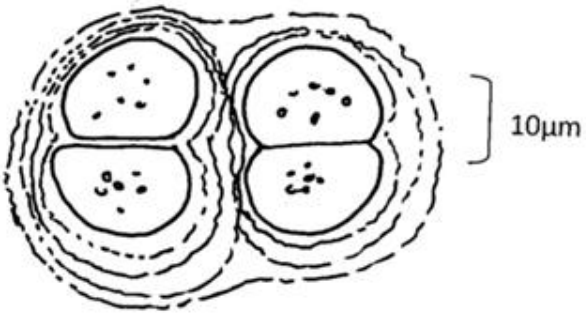

Fig. 6. *Chroococcus turgidus*

Fig. 7. *Chroococcus varius*

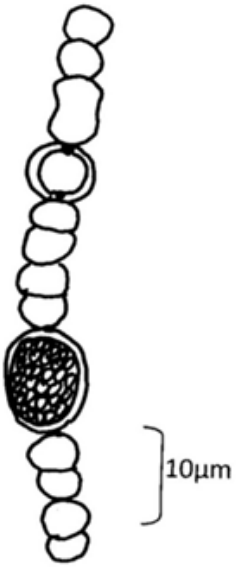

Fig. 8. *Anabaena affinis*

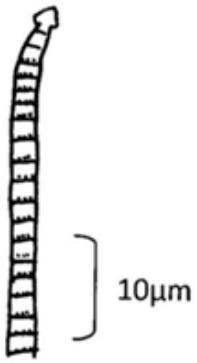

Fig. 9. *Oscillatoria amoena*

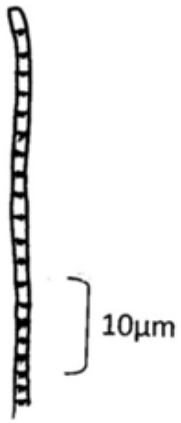

Fig. 10. *Oscillatoria amphibia*

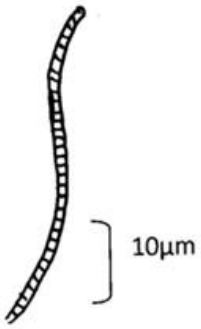

Fig. 11. *Oscillatoria angustissima*

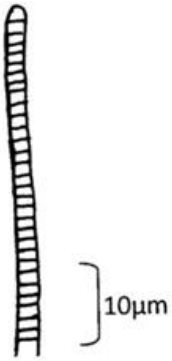

Fig. 12. *Oscillatoria formosa*

Fig. 13. *Oscillatoria prolifica*

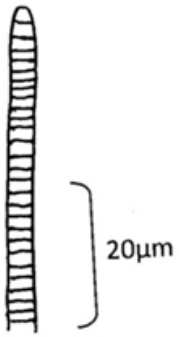

Fig. 14. *Oscillatoria subbrevis*

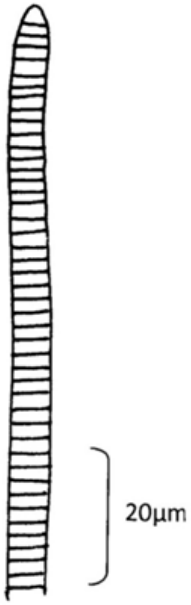

Fig. 15. *Oscillatoria tenuis*

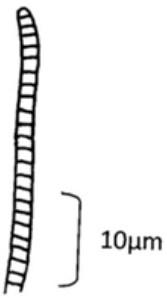

Fig. 16. *Oscillatoria terebriformis*

Fig. 17. *Spirulina subsala*

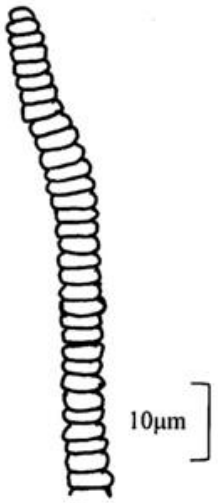

Fig. 18. *Lyngbya arboricola*

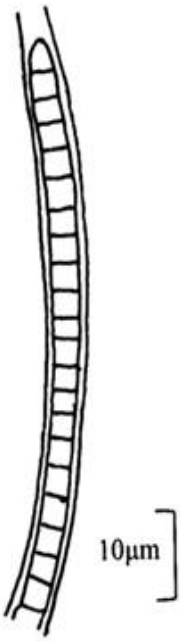

Fig. 19. *Lyngbya tylorii*

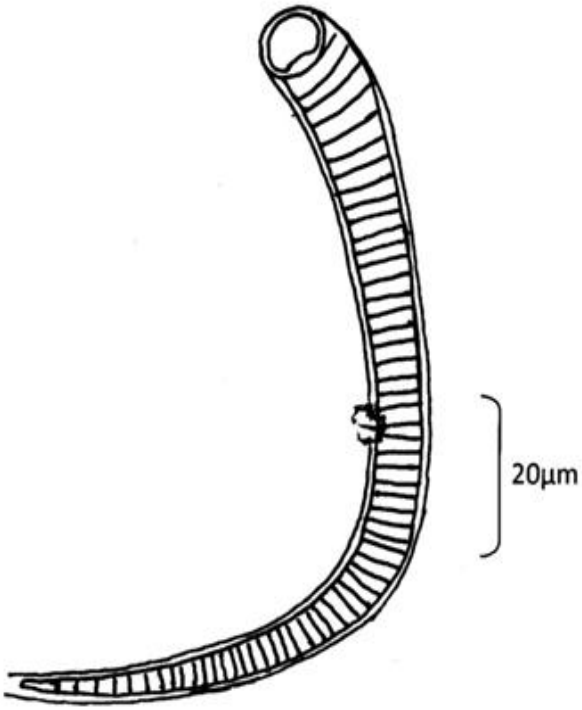

Fig. 20. *Calothrix fusca*

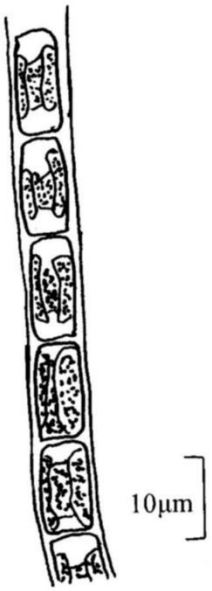

Fig. 21. *Ulothrix aequalis*

Fig. 22. *Ulothrix tenuissima*

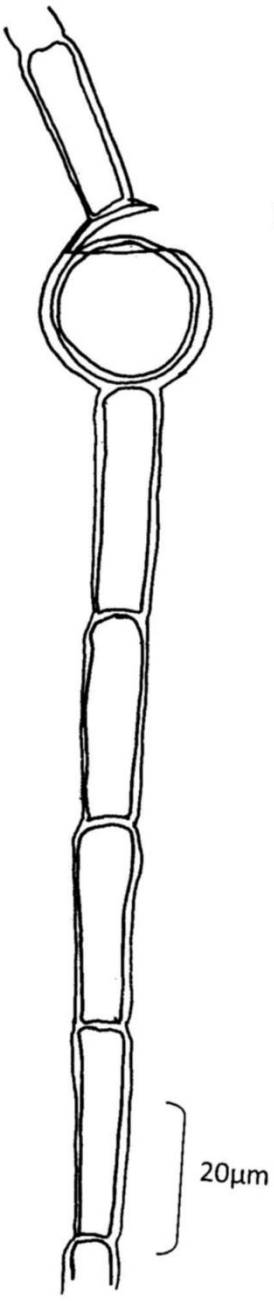

Fig. 23. *Oedogonium behemicum*

Fig. 24. *Cymbella ehrengbergii*

Fig. 25. *Cymbella turgida*

Fig. 26. *Cymbella venticosa*

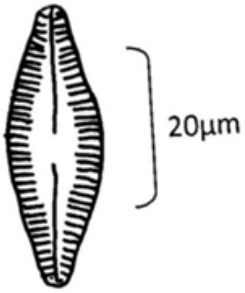

Fig. 27. *Navicula confervacea*

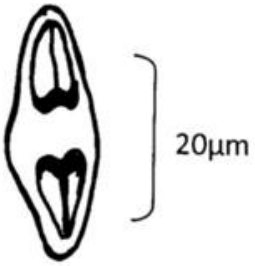

Fig. 28. *Navicula knsnesis*

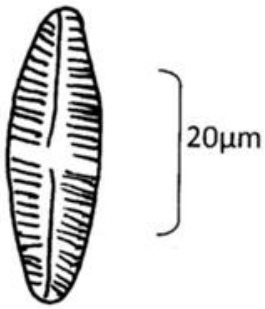

Fig. 29. *Navicula mutica*

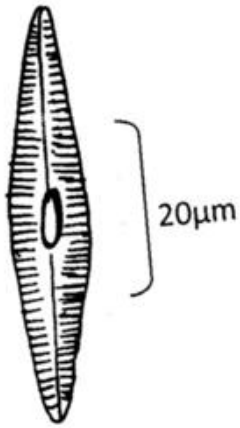

Fig. 30. *Navicula lanceolata*

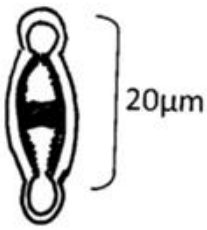

Fig. 31.*Navicula viridula*

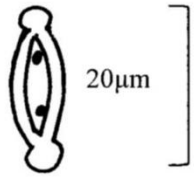

Fig. 32. *Achnanthes hungarica*

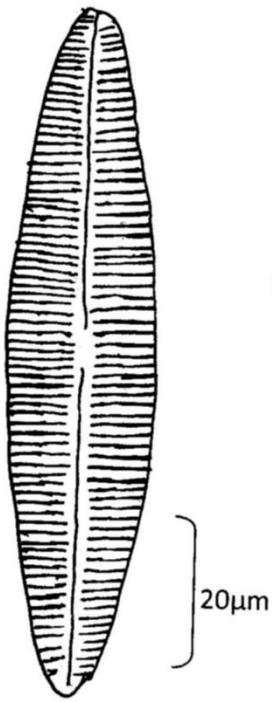

Fig. 33. *Achnanthes minutissima*

Fig. 34. *Cyclotella operculata*

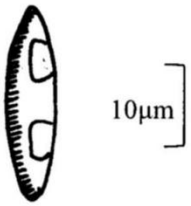

Fig. 35. *Pinularia interrupta*

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